The Supply Side of Health Care

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[1] This research was performed at Inforum at the University of Maryland. The corresponding author is Jeffrey Werling, Executive Director of Inforum. Questions may be directed to werling@econ.umd.edu or (301) 405-4607. More information about Inform and author biographies may be found at www.inforum.umd.edu. A summary paper on this topic was prepared with support from the Office of the Actuary in the Centers for Medicare and Medicaid Services and published in the *Survey of Current Business* in April 2014; it may be found at www.bea.gov/scb/index.htm. Additional information about this paper and the published edition is available www.inforum.umd.edu/services/projects/supplysideofhealthcare.html.

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Abstract

There is a common assertion that health care is over one-sixth (or about 18 percent) of the economy. This conclusion, however, is based only on a measure of health care demand. It is much more difficult to identify a corresponding ratio in the supply side data of the economy, that is, in terms of value added and employment.

Our work reconciles information about the supply and demand sides of the national health sector. We use input-output techniques to link the final demand values from the National Health Expenditure Accounts (NHEA) to domestic production and imports of commodities, industry value added, and industry employment. We translate NHEA levels by spending categories (hospitals, physicians, drugs, devices, insurance, construction, investment, research, etc.) into equivalent National Income and Product (NIPA) final demand concepts and then translate these products and services expenditures into final demand by commodity. We then use input-output accounting to determine, by sector, the total output, value added, and employment levels required to satisfy health care demand. The value added and employment levels are identified not only for medical service sectors but also for medical manufacturing industries and for supporting sectors such as distribution, support services, and government production. We find that in 2012, health care production required about 15.4 percent of total value added and 18.7 percent of civilian employment. In addition, domestic health care demand required about 1.5 percent of GDP in imports.

1. Introduction

In 2012, the Centers for Medicare and Medicaid Services (CMS) estimated that the American private sector, including consumers, and the government spent almost $2.8 trillion on health care related goods and services. This figure is called National Health Expenditure (NHE) and is the topline figure from CMS's detailed National Health Expenditure Accounts (NHEA). [2] The size of health care expenditures, typically measured in proportion to GDP, has risen from 5 percent of GDP in 1960 to over 17 percent in 2012, a rapid rise that is likely to continue. Despite this trend, however, surprisingly little is known about the structural economic detail of health care industry production in terms of gross output, value added, and employment. In particular, when assessing the existing data on health care expenditures, it is important to recall that the NHE-to-GDP ratio reflects the demand side of the economy and not the supply side. To date, there is little research concerning the total primary factor requirements of satisfying health care demand, in particular the labor requirements. Yet an understanding of such requirements can shed a greater light on the sustainability of spending trends.[3]

The present study provides a comprehensive accounting of health care production. Our starting point is health care demand as defined by the NHEA. To translate these expenditures into supply by industry, we convert the NHEA dollar-based figures to corresponding NIPA-based final demand categories, and then use standard input-output (IO) accounting to determine the value-added and labor requirements by industry. More specifically, we use modified versions of the Bureau of Economic Analysis' industry and input-

[2] See Centers for Medicare and Medicaid Services (CMS) (2011). NHEA reports and data may be found at www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/NationalHealthExpendData/NationalHealthAccountsHistorical.html.

[3] The lack of a health care supply-side was highlighted by Gene Steuerle (February 24, 2009).

output accounts to provide health care supply estimates including: 1) the direct and indirect gross output requirements by commodity, 2) the direct and indirect imports by commodity, 3) the value added by industry, and 4) the employment requirements by industry. This framework provides new analytic capabilities to provide better understanding of the supply side of health care, thus improving not only our understanding of the past but also our ability to anticipate needs and developments.

The paper is organized as follows. In the first section below, we describe the NHEA and show that such demand-side accounting alone does not provide information on the resource requirements of health care production. The second section summarizes the available data sources and their limitations, and it describes the input-output methodology used to determine the gross output requirements of satisfying health care demand. In the next section we provide the most salient results of the analysis, that is, the industry-level value added and employment associated with providing health care. These findings are compared to other recent works concerning health care employment. We conclude with an agenda for future research.

2. The Demand and Supply of Health Care

Health Care Demand: National Health Expenditures (NHE)

As the nation struggles with decisions concerning the provision and financing of health care, an oft-cited symptom of problems is that "the cost of health care is rising too fast." This conclusion is based at least partly on the observation that the growth of nominal expenditures for health care goods and services almost always exceeds the increased of nominal gross domestic product (GDP). Figure 1 shows the growth rate of total nominal NHE versus the rate of nominal GDP from 1960. Through 2009, NHE growth outstripped GDP growth almost every year, often by a wide margin. This difference in growth rates is often called "excess health care cost." Only from 1994 to 2000, and more recently from 2009-2012, has the rate NHE growth been similar to GDP growth.

Total NHE, in proportion of GDP, typically is cited as indication of the footprint of the health care sector on the overall economy. Figure 2shows that health care is a large and growing portion of the national economy. Since 1960, expenditures have grown from about 5 percent of GDP to over 17 percent. This increase, of course, follows from the mismatch in growth rates shown in Figure 1. Some observers suggest that an ever-rising health care share of total expenditures eventually will displace other desirable purchases of goods and services.[4] Indeed, when experts discuss measures that could "bend the curve" of health care costs, they refer to the relationship depicted in Figure 2.

Health care expenditures in the NHEA are defined as the total private consumption, capital investment, and government expenditures for health care goods and services. The NHEA contains health care expenditure data for different types of goods and services expressed in current dollars, as shown in Table 1.[5] The health care expenditures normally used for analysis are adjusted neither for general inflation nor for relative price changes.[6]

[4] See, for example, Chernew, (2009).

[5] For a brief reference of the goods and services definitions of the NHE, see www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/NationalHealthExpendData/Downloads/quickref.pdf.

[6] CMS publishes an NHE general health care price index, which is shown near the bottom of Table 1. To build this general index, it uses several price indices for different goods and services assembled from other sources and it often uses these prices in internal research. The real NHEA quantities, however, rarely are used for health care research.

An important feature of the NHEA is that they correspond to the expenditure definition of GDP used in the National Income and Product Accounts (NIPA).[7] This concept specifies GDP as the sum of private consumption (*C*), capital investment (*I*), government expenditures (*G*), and exports (*X*) minus imports (*M*):

$$GDP = C + I + G + X - M \tag{1}$$

As noted above, NHEA expenditures comprise portions of C, I, and G and are valued at the prices paid by the final purchasers.

In 2012, total personal health care (PHC) was over $2.3 trillion, or about 85 percent share of total NHE, and it is the most important line item in the NHEA. As indicated by Table 1, PHC itself is composed of 10 types of goods and services, such as physician and clinical services and prescription drugs. Including the share of premiums paid by their employers, consumers lay out a substantial amount ($164.3 billion in 2012) for the net cost of private health insurance (premiums minus claims). Both PHC and net premiums are classified in the NIPA as personal consumption (C). The other sources of demand in the NHEA come from private investment in capital equipment and structures (I) and from federal, state and local government consumption and investment spending for health administration, research, and public health activities (G).

The Bureau of Economic Analysis provides a different but similar accounting for health care expenditures within the context of the national income and product accounts (NIPA). Kornfeld and others (Hartman, Kornfeld, & Catlin, 2010) have provided a description of both sets of accounts with details on the differences. Especially in terms of the big and broad categories of spending such as ambulatory care, hospitals, and insurance, the figures are very similar across the BEA and CMS health care demand accounts. Neither account, however, contains supply side data.

Health Care Supply: Substantially Hidden within Published Data

Detailed demand-side content of the NHEA is not sufficient for thorough analysis of health care macroeconomics, particularly those analyses that concern supply-side issues such as production patterns and employment. For instance, expenditures for physician services that are paid either directly by patients or on behalf of patients by insurance companies and government programs are equivalent to the total revenue of the physician sector. The figures do not show, however, how much physicians pay for supplies, utilities, and outside services. They do not provide the wage and capital income received by physicians, their employees, their landlords, their bankers, and government. Since they reflect demand and not supply, the NHEA cannot tell us much about the magnitude and composition of health care employment.

In national accounting, the supply side of the economy is focused on determining the primary income, or "value added," for each of the industries that comprise the economy. In the physician sector, for instance, total value added may be calculated by deducting from physician revenue any intermediate purchases for supplies, utilities, and services. Value added includes labor compensation (W), capital income (P, including profits, rent, interest, and depreciation), and net indirect taxes (T, including production and imports taxes minus subsidies) paid by the sector.

[7] The NIPA are developed and maintained by the Bureau of Economic Analysis (BEA). Data for each of these terms are reported in the first table of the NIPA and are available at http://www.bea.gov/national/index.htm.

Figure 1: Growth in Nominal NHE vs Growth Rate of Nominal GDP

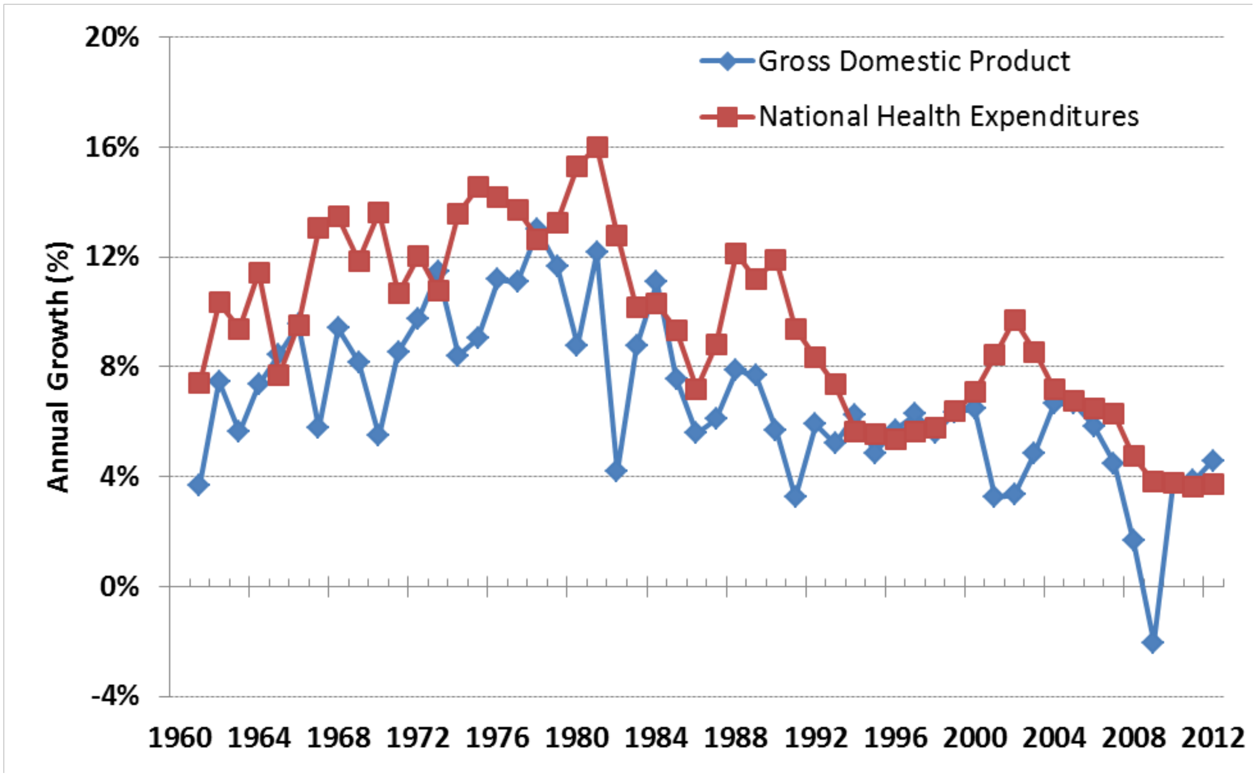


Figure 2: Nominal NHE as a Percent of GDP

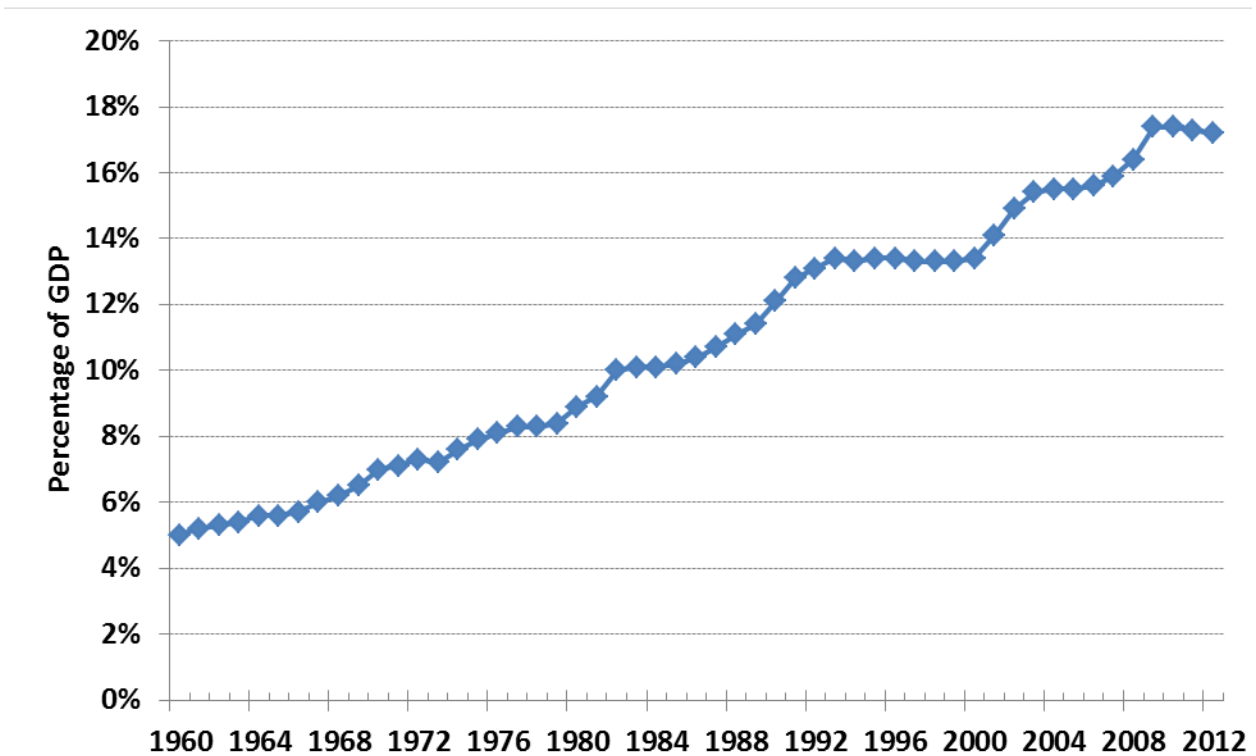


Table 1: National Health Expenditures, 1960-2012

	Billions of U.S. Dollars				Annual Percent Growth	
	1960	1980	1998	2012	1960-2012	1998-2012
Gross Domestic Product (GDP)	**543.3**	**2862.5**	**9089.1**	**16244.6**	**6.8**	**4.2**
National Health Expenditures	**27.4**	**255.8**	**1208.9**	**2793.4**	**9.3**	**6.2**
NHE as percent of GDP	5.0	8.9	13.3	17.2	2.4	1.9
Personal Health Care	23.4	217.2	1029.2	2360.4	9.3	6.1
Hospital Care	9.0	100.5	374.9	882.3	9.2	6.3
Physician & Clinical	5.6	47.7	258.7	565.0	9.3	5.7
Dental Services	2.0	13.4	53.8	110.9	8.0	5.3
Other Professional Services	0.4	3.5	33.8	76.4	10.7	6.0
Home Health Care	0.1	2.4	34.2	77.8	14.9	6.1
Nursing Home Care	0.8	15.3	79.4	151.5	10.6	4.7
Other Health Services	0.5	8.5	56.1	138.2	11.6	6.6
Prescription Drugs	2.7	12.0	88.4	263.3	9.2	8.1
Other Non-Durables	1.6	9.8	28.6	53.7	7.0	4.6
Durables Medical Products	0.7	4.1	21.3	41.3	8.0	4.8
Net Cost of Private Insurance	1.0	9.3	49.7	164.3	10.3	8.9
Government Administration	0.1	2.8	13.2	33.6	13.2	6.9
Public Health Activities	0.4	6.4	37.5	75.0	10.7	5.1
Research	0.7	5.4	21.5	48.1	8.5	5.9
Equipment	0.4	6.1	34.2	61.6	10.2	4.3
Structures	1.5	8.6	23.7	50.3	7.0	5.5
	100 = 2009				Annual Percent Growth	
GDP Deflator	17.5	44.5	78.9	105.0	3.5	2.1
Health Care Price Deflator	9.2	28.3	72.1	106.9	4.8	2.9
	Billions of 2009 Dollars				Annual Percent Growth	
Real GDP	3105.8	6443.4	11513.4	15470.7	3.1	2.1
Real Health Care Expenditures	296.3	903.0	1677.5	2613.1	4.3	3.2

The enumeration of value added by industry is the key component of the supply side of national accounts. The sum of value added across industries provides an alternative "supply-side" definition of GDP:

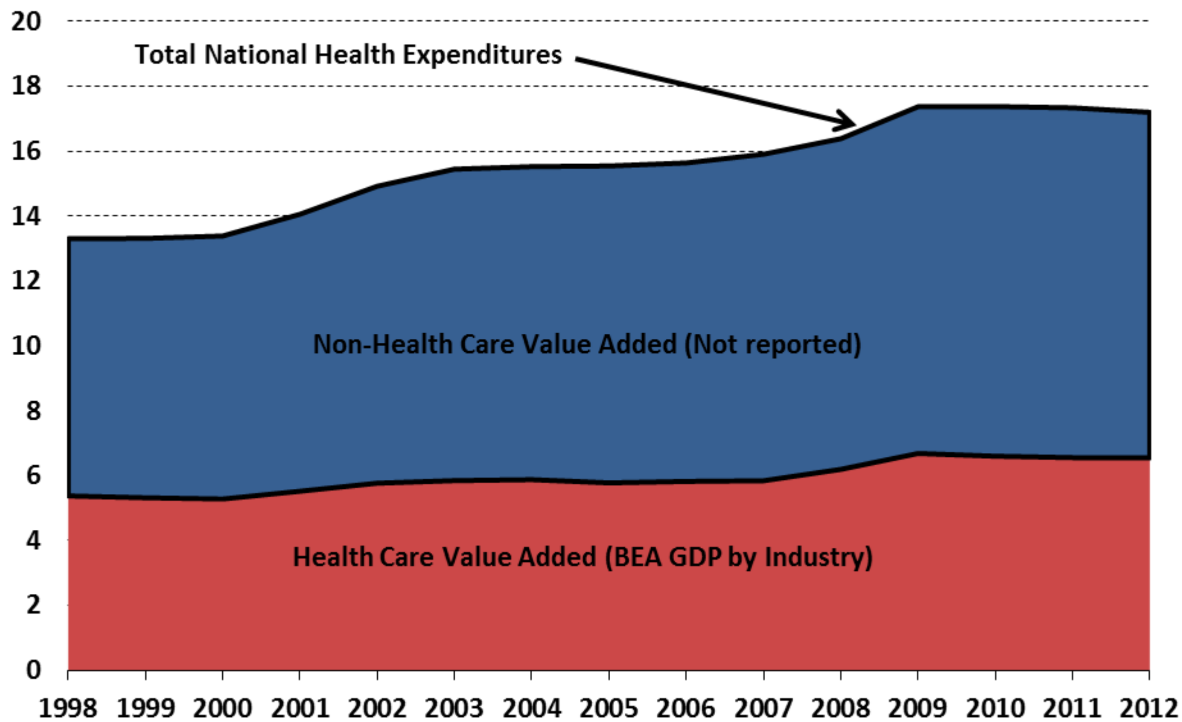
$$GDP = \sum_j VA_j = \sum_j \left(W_j + P_j + T_j\right) \qquad (2)$$

Since the circular flow of macroeconomic expenditure (demand) and income (supply) are consistent, then these apparently different measures in fact produce the same result:

$$GDP = C + I + G + X - M = \sum_j VA_j \qquad (3)$$

For the U.S. economy, industry-level value added (income) data are published as the "GDP by Industry Accounts" by the BEA.[8] In addition to total value added by type, the industry accounts also contain industry figures for nominal and real output and total and full-time equivalent (FTE) employment. Of the 65 unique industries identified in these accounts, only two of them clearly are "health care industries:" 1) Ambulatory health care services and 2) Hospitals and nursing and residential care. The combined value added (supply) of these two sectors was 6.5 percent of GDP in 2012, well short of health expenditures' (demand) share of 17.2 percent of GDP. The respective shares are shown in Figure 3. BEA also provides employment estimates for the 65 value added industries. The two "mega" health care sectors combined for 9.9 percent of economy-wide employment in 2012, still well short of the expenditure share.

Figure 3: Total NHE and Health Care Industry Value Added (Percent Share of GDP)



One reason for these apparent gaps is that some important health care activities are subsumed in other categories. Among these are pharmaceutical manufacturing which is combined with the broader chemicals industry, electro-medical and therapeutic apparatus manufacturing which is part of computer and electronic products, and medical equipment and supplies manufacturing which is part of miscellaneous manufacturing. However, even when we use other data to estimate value added by such sub-industries and add it to the two large health care sectors, the measure of total supply still does not approach the total demand as measured by the NHEA. A shortfall remains for three reasons.

First, the final demand expenditures for health care pay not only the income of health care direct providers (physicians and staff) but also cover other expenses of the health care sector, including purchases of energy, materials, and services. Production of these intermediate inputs also generates income, or value

[8] At the time of this writing, the GDP by industry dataset presents a slightly different concept than corresponding measures reported in the NIPA. However, the differences are minimal and easily reconciled in the process of developing a consistent interindustry accounting framework. BEA plans to produce completely integrated accounts in connection with the release of the 2007 benchmark input-output table.

added, in the industries that supply them. For instance, when a hospital purchases electricity, part of the bill pays workers in the electric utility sector (thus increasing value added) and some of it is used to purchase materials like coal. In turn, a portion of the expenditure for coal is used to pay miners for their labor, thus increasing value added in the coal industry. In this way, satisfaction of health care demand requires value added across the supply chain, even in those seemingly unrelated industries like coal mining. We can track the required upstream purchases and the associated value added via "interindustry" accounting methods that are reflected by input-output tables. These tables show, for instance, the purchases of electricity by hospitals in absolute terms, and they can be used to calculate electricity purchases in proportion to total hospital revenue.

A second large component of health care expenditures that is not paid to health care suppliers is the margins garnered by wholesalers and retailers that distribute medical goods and services. These particularly are significant for prescription drugs and other medications and for medical supplies and equipment. Additional margins go to the transportation sectors that transfer supplies from factory or port to wholesalers and to retailers.

Finally, domestic supply might fall short of demand because foreign suppliers satisfy some demand for health care. For instance, about 45.4 percent of U.S. demand for pharmaceutical products is satisfied through imports. Not only are imports used to supply final demand directly, but they also help to supply intermediate purchases, particularly for goods and energy. We will have more to say about imports below.

In summary, the health care demand figures supplied by the NHE provide no information concerning the commodity production, import penetration, and industrial income and employment composition of health care supply. While health care supply includes obvious sectors such as hospitals and doctors, demand also is satisfied indirectly by almost every sector of the economy, including agriculture, mining, construction, and entertainment services.

In the following sections, we develop an input-output (IO) framework to provide better understanding of the supply side of health care. In the IO construct, health care goods and services are not produced only in the hospital room or the doctor's office. They are also produced by the outside accountant who balances the doctor's books and the utility that supplies his electricity. The IO calculations therefore identify which industries contribute the value added for health provision, thus filling in the missing data of Figure 1.

Similarly, the IO framework can calculate the allocation of labor among health and non-health care sectors. For instance, if a large and growing segment of the retail sector is devoted to the distribution of health care goods and services, then should an equivalent proportion of retail employment be assigned to health care when calculating comprehensive health care employment levels?

The results from these calculations are important because they provide a consistent accounting of the health care supply side that allows us to trace changes in factor payments and employment through time. In turn, the historical accounting can provide an important indication of the sustainability of health care growth in the future.

3. Methodology

The LIFT Model of the U.S. Economy

Much of the work at Inforum involves the Long-term Interindustry Forecasting Tool (LIFT),[9] a dynamic interindustry model of the U.S. economy. LIFT is also a macroeconometric model that determines macroeconomic quantities that are consistent with the underlying industry detail. Most relevant for this study is the model's database that contains a full input-output (IO) structure populated with time series data that generally are consistent with the published BEA Input-Output, GDP by Industry, and NIPA data.

The core of this data is a historic time series of 110 x 110 commodity IO tables with consumption, investment, government, export, and import final demand data from 1998 through 2012. These tables have been developed from the BEA annual tables and the 2002 benchmark IO table, but the LIFT data set contains more detail for health care demand and supply compared to those provided by the BEA annual input output tables. Such detail is essential for our study of demand and production of health care services and of pharmaceuticals, electromedical machinery, and medical equipment and supplies. In addition to the supply and demand by commodity sector, the LIFT model also features industry output, value added, and employment for the BEA 65-industry classification, together with the annual "make" matrices to link commodity output with industry output. The LIFT model thus is particularly suited for the present study, as its framework reflects the standard input-output methodology employed in this paper, and it rests on a database that is consistent with the published data cited earlier.

In the LIFT database, GDP, final demand aggregates, and other macroeconomic information, as well as industry employment levels, are provided by the BEA's NIPA publications. The BEA also publishes annual industry output levels and value added by industry for 65 and industries from 1998 through 2011. Additional input-output detail was published in the 2002 benchmark tables. The input-output data sets include bridge tables that map final demand (i.e. consumption by types of consumer goods and services, equipment and software investment by purchasing industry, and construction spending by type of structure) to the commodities that comprise the purchased goods and services.

Caveats and Weaknesses of the Analysis

Below we describe a recipe for obtaining health care value added and employment by industry from the NHEA. Any use of IO analysis in this fashion is subject to several caveats. First, like any other national accounting exercise, the compilation of the BEA input-output accounts involves a myriad of assumptions and imputations to fit census and survey data into the accounting framework. The 1997 and 2002 benchmark IO tables provide very detailed information by commodity and industry. In order to provide insight into the year-by-year evolution of the economy, however, we use the BEA annual input-output tables from 1998 through 2011 that themselves are based on the 1997 and 2002 benchmark IO tables, and these in turn are based on economic censuses. There are many important parameters such as trade and transport margins that are not observed in the non-census years and therefore are estimated by BEA to compile the annual tables.

Moreover, the 65 sectors of the BEA annual IO and industry data provide insufficient detail for health care products, industries, and final demand. We therefore turn to the LIFT model database that contains more detail, particularly for health care expenditures and production. These details, of course, also are estimated using the benchmark and annual tables together with other information (mostly from the NIPA). While the

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[9] Addition information about Inforum, a research center at the University of Maryland, and the LIFT model may be found at www.inforum.umd.edu/services/models/lift.html. The Lift model is described in the Appendix: The LIFT Model of the U.S. Economy.

various columns and rows are constrained to sum to aggregate figures similar to the published IO, industry, and national accounting data, there is no way to test whether individual table entries coincide with actual but non-observed values.

As discussed below, the correspondences between NHEA concepts and national accounting concepts are not exact. While the nature of these discrepancies is known, the exact allocation, mapping values from one data set to the other, is not known for each year. Finally, IO analysis invariably relies on ratios (e.g., value added over output or imports over domestic demand) that, while documented for broad industries or on a national basis, may not necessarily hold in the specific case for which the analysis is applied. For example, the analysis below uses the overall value added to output ratio for retailing to estimate the retail component of health care employment. To the extent that the overall ratio is different than the actual ratio for retailing of drugs and other medical supplies, the estimate will be imprecise. However, these sources of error are common not only to IO calculations but to any economic analysis using aggregate and industry data.

Reconcile NHE PHC and Net Private Insurance to NIPA PCE Expenditure Levels

Because the NHEA provides the foundations for total health care spending measures and the NIPA and BEA industry data provide the statistical basis for constructing the supply account, we must identify the relationships between the data sets and reconcile any inconsistencies. Fortunately, the BEA has identified a relatively detailed crosswalk from the NHEA to NIPA concepts.[10]

The first objective is to allocate the detailed NHEA values for personal health care and net private insurance to the corresponding NIPA final private consumption categories. The NHEA concepts for PHC are equivalent to the Personal Consumption Expenditures (PCE) reported in the NIPA. That is, the figures from each source represent all transactions between individuals and providers, including expenditures paid through private insurance and government programs like Medicaid and Medicare. The goods and services definitions reported in the NHEA are similar to those of the NIPA, but there are differences. The BEA correspondence tells us, for instance, that the NHEA physician and clinical expenditures are spread across several categories of NIPA PCE including physician offices and other professional medical services. On the other hand, NHE prescription drugs spending maps directly to prescription drugs PCE. Net insurance premiums in the NHE also map neatly into PCE.

In the NHEA, structures investment is the value of new construction, additions, alterations, and major mechanical or electrical upgrades put in place by the two main industries within the medical sector, that is, the ambulatory care and hospital sectors. While the measure includes doctors' offices and nursing homes, it excludes, for example, pharmacies and other commercial buildings that are not part of the two main medical sectors.

Similarly, the equipment investment component of the NHEA is the value of new capital equipment (including software) purchased or put in place by the medical sector. It therefore does not include equipment investment by pharmaceutical manufacturers, medical equipment makers, or retail establishments such a pharmacies. The capital equipment investment measure includes all capital equipment purchased by medical establishments, and therefore it is not limited to medical machinery or equipment but includes, for example, vehicles and computer equipment.

Translate Final Demand by Product into Final Demand by Production Commodity

Payment for purchases of many health care good and services does not accrue to a single production sector. Accordingly, health care spending for NIPA PCE and for equipment and structures investment is

[10] A detailed version of the accounting is found in Hartman, Kornfeld, and Catlin (2010).

distributed across LIFT sector production commodities via transactions summarized in the LIFT model bridge (share) tables for consumption, equipment investment, and construction. The bridge matrix for consumption relates spending by consumers to the purchases of various commodities that comprise the purchased good or service. For instance, the bridge shows how consumer spending on pharmaceuticals is distributed among retailers, wholesalers, transportation providers, and drug manufacturers. The investment bridge table, or capital flow matrix, shows the type of equipment purchased by hospitals and other medical care providers, including the part of the investment dedicated to transportation and trade margins, engineering, and brokerage services.[11] The construction matrix shows, for instance, the commodity inputs that go into building hospitals and other facilities.

NHE for government administration is the cost of maintaining Medicare, Medicaid, and other programs. Thus, all of the administrative costs are allocated directly to the final demand from the government production sector. Approximately half of the expenditures for public health activities and research are allocated to private professional, health, education, and non-profit sectors. These allocations are made using the sales of these sectors to government as indicated by the input-output tables. The other half of public health and research is allocated to final demand for government administration and enterprises.

Table 2 shows, in the left-most column for each year, the direct health care demand levels from the NHEA as distributed among input-output production commodities for 1998 and 2012, including the compound annual growth rates between the two years.[12] The commodities are ranked by the size of health care demand in 2012. The greatest expenditure category is for health care services such as hospitals ($826.2 billion in 2012), offices of health care professionals ($597.0), nursing and residential care facilities ($214.3), and other ambulatory care ($170.6). Final demand for retail ($182.8 billion) and wholesale ($103.1) trade also is large. Think of the pharmacies on every corner and in every grocery store, including the services of the pharmacist inside. Among the largest sectors, the fastest growing commodity demands from 1998 to 2012 are for insurance (8.9%), retail trade (7.8%), and wholesale trade (11.5%).

Calculate Domestic Health Care Commodity Demand

To distinguish the activities of the domestic supply chain, we must separate the final demand that will be satisfied through imports. Direct imports are determined for each commodity by multiplying the LIFT import share of domestic demand for each commodity by the corresponding domestic demand level. Then,

$$f^d = f - f^m \tag{4}$$

where f^d is a vector of health care expenditure by commodity from domestic sources, f is the vector of total commodity demand as described above, and f^m is the health care direct imports by commodity.

Table 2 shows the direct imports in each year's second column. For most of the health care services sectors, imports are trivial or nonexistent, but they are significant for pharmaceuticals. In 2012, out of $151.0 billion of pharmaceutical demand, $68.6 billion was imported. Nevertheless, total direct health care imports are relatively small, reaching $107.4 billion, or 0.7 percent of GDP and 3.8 percent of NHE, in 2012. The difference between total demand and demand for import, domestic final demand across commodities, is shown for each year in the third column of Table 2.

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[11] The current generation of BEA IO tables does not include a capital flow table that could translate industry investment to commodity demand. Fortunately, the LIFT model includes a capital flow table that has been constructed from the 1997 benchmark IO table and the BEA Fixed Asset database.

[12] There are 110 commodities in the LIFT model, but only the commodities with the greatest NHE demand are shown.

Table 2: Direct NHE Final Demand by LIFT Commodity

	Billions of Dollars						Annual Percent Growth		
	1998			2012			1998-2012		
LIFT Commodity	Health Care Direct Demand	Direct Imports	Domestic Direct Demand	Health Care Direct Demand	Direct Imports	Domestic Direct Demand	Health Care Direct Demand	Direct Imports	Domestic Direct Demand
Total National Health Expenditures	**1208.9**	**24.4**	**1184.6**	**2793.4**	**107.4**	**2686.0**	**6.2**	**11.2**	**6.0**
94 Hospitals	360.3	0.1	360.2	826.2	0.4	825.8	6.1	12.2	6.1
92 Offices of physicians, dentists, other practioners	285.3	-	285.3	597.0	-	597.0	5.4	-	5.4
95 Nursing and residential care facilities	104.7	-	104.7	214.3	-	214.3	5.3	-	5.3
62 Retail trade	64.1	-	64.1	182.8	-	182.8	7.8	-	7.8
93 Other ambulatory health care services	73.6	-	73.6	170.6	-	170.6	6.2	-	6.2
79 Insurance	49.7	1.2	48.4	164.3	18.4	145.9	8.9	21.4	8.2
27 Pharmaceuticals	63.3	15.4	47.9	151.0	68.6	82.5	6.4	11.3	4.0
61 Wholesale trade	22.4	-0.6	23.0	103.1	-1.9	105.0	11.5	8.1	11.5
91 Home health care services	47.5	-	47.5	88.1	-	88.1	4.5	-	4.5
107 General government industry	28.4	-	28.4	65.2	-	65.2	6.1	-	6.1
13 New construction	21.8	-	21.8	46.7	-	46.7	5.6	-	5.6
85 Professional, scientific and technical services	15.3	0.1	15.2	33.4	0.5	33.0	5.8	11.9	5.7
58 Medical equipment and supplies, dental labs	12.9	1.7	11.2	32.6	8.0	24.5	6.8	11.8	5.7
90 Educational services	15.9	0.0	15.9	31.9	0.1	31.8	5.1	14.3	5.1
106 State and local government enterprises	10.2	-	10.2	21.2	-	21.2	5.3	-	5.3
45 Electromedical and electrotherapeutic apparatus	8.1	2.2	6.0	14.9	5.0	10.0	4.5	6.2	3.7
59 Ophthalmic goods	4.2	1.8	2.4	8.8	3.6	5.2	5.4	5.2	5.6
66 Truck transportation	2.2	0.0	2.2	6.8	0.1	6.7	8.2	9.2	8.2
86 Computer systems design and related services	3.1	0.0	3.1	6.6	0.1	6.5	5.5	14.6	5.4
All Other Commodities	16.0	2.6	13.4	27.9	4.6	23.3	4.0	4.2	4.0

Calculate the Domestic Total Gross Output Requirements by Commodity

To determine the level of domestic production that is consistent with net final domestic health care demand by commodity (denoted as vector f^d), we employ the input-output accounting identity[13]

$$q^d = A^d \times q^d + f^d \quad (5)$$

where q^d is a vector of the gross domestic outputs required to produce f^d, and where A^d is an $n \times n$ matrix of coefficients ($a_{i,j}$) representing the domestic sales of each row (i) product used in the production of one unit of the column product (j). The total gross output requirements is inclusive of all intermediate costs and the value added required by the commodity production. The input-output matrix A^d indicates the "recipe" for production of a dollar's worth of output, where the ingredients are assembled from available domestic commodities. It indicates that in 2012, for example, hospitals used 8.1 cents of real estate services per $1 of hospital revenue, and doctor offices used 2.4 cents of net insurance services for every $1 worth of output. Thus, the product $A^d \times q^d$ indicates intermediate inputs, that is the quantities of materials, utilities, and purchased services employed in the production process for producing the vector q^d. In the current calculation, we solve for the production levels q^d that are required to satisfy net final demand levels f^d, including the corresponding intermediate input requirements, as

$$q^d = (I - A^d)^{-1} \times f^d \quad (6)$$

Compute Indirect Import Requirements

A second import "leakage" of demand results from the imported content of indirect production. For example, domestically made medical imaging equipment contains foreign-produced components. These indirect imports are calculated by multiplying the intermediate import coefficients matrix by total domestic requirements.

$$m^{indirect} = A^m \times q^d \quad (7)$$

Compute Direct and Indirect Domestic Output Requirements

The vector q^d elements are the "total domestic gross outputs requirements" by commodity for producing NHE. As is customary in input-output economics, we define a vector of *direct* domestic gross output by production commodity that is equal to the final demand by commodity (i.e. $q^{direct} = f^d$). Then we can determine the "indirect requirement" ($q^{indirect}$) vector as the difference between total production and direct production requirements:

$$q^{indirect} = q^d - q^{direct} \quad (8)$$

Indirect requirements are the materials and services that are purchased for intermediate use in the production of health care commodities. An example is the electricity employed to power a hospital. Of course, additional production is needed to support provision of the materials and services employed in direct production of health care, such as the coal that is needed to produce electricity used by hospitals. The chain of upstream activities are accumulated in indirect production.

Table 3 provides direct, indirect, and total "health care" commodity output for the years 1998 and 2012 and the compound average annual growth rate between those years. The commodity sectors are ranked by total output requirements (the third column for each year) in 2012. Note that direct output figures (the first column for each year) are the same as the domestic direct demand in Table 2 (the third column for each year). In terms of total output, the largest sectors are those with the largest direct demands such as

[13] For more information on input-output methods, an extensive review of the subject is available in Miller and Blair (2009).

hospitals, physician offices, and insurance. As is typical in the IO literature, total "duplicated" output requirements are about 1.6 times the amount of final demand.

Table 3 shows that the big health care sectors have minimal indirect output. Indirect production requirements (the second column for each year) are important for insurance ($82.7 billion in 2012), professional scientific and technical services ($151.3), real estate ($161.0), administrative and support services ($130.0), and management of companies and enterprises ($116.5). Obviously, these all are large input suppliers to the health care industry.[14] Insurance has large amounts of both direct and indirect of production.

Determine Total Industry Gross Output Requirements

The input-output calculations are conducted on a product, or commodity, basis. Commodities refer to goods and services rather than to the industries that make them. Because each industry can make a variety goods and services, for production analysis it is more theoretically sound and empirically accurate to use product-to-product tables rather than product-to-industry tables. Value added and employment, however, are characterized and reported by BEA for 65 industries. We employ the LIFT model "make" matrix to translate production by commodity into gross production by industry. This matrix is adapted from the annual BEA IO tables, and it identifies for each industry (row) the quantity of each product (column) produced. Converting it to a share matrix and multiplying it by the total requirements output vector provides gross health care output by the 65-industry BEA classification:

$$q^{industry} = make^{d} \times q^{d} \tag{9}$$

4. Results: Health Value Added and Employment by Industry

Health Care Value Added for Each Industry

Once we have health care total gross output by industry, we calculate health care value added for each industry (hva_j) by multiplying the total gross output requirements for each industry by the corresponding historical value added-to-industry output ratios taken from the BEA GDP-by-industry accounts:

$$hva_j^{industry} = \frac{va_j^{bea}}{q_j^{bea}} \times q_j^{industry} \tag{10}$$

In this way, we separate health-care related industry revenue into value added by industry ($hva_j^{industry}$) and payments for intermediate goods and services. Table 4 shows the figures by industry for 1998 and 2012 for all major industries and for the sub-industries with the largest value added. These numbers represent the wage, capital, and indirect tax income generated, directly and indirectly, by industries as they respond to satisfy the demand for health care.

[14] The output figures, of course, include double counting of intermediate inputs. For example, the services bought by hospitals and medical offices is part of indirect output of those sectors. However, this value also is counted as part of the sales of the direct medical services. We therefore cannot aggregate indirect production or add indirect production to direct production and expect to obtain meaningful figures.

Table 3: Total, Direct, and Indirect Gross Output Requirements for Supplying NHE

	Billions of Dollars						Annual Percent Growth		
	1998			2012			1998-2012		
LIFT Commodity	Direct Domestic Output	Indirect Output	Health Care Total Domestic Output	Direct Domestic Output	Indirect Output	Health Care Total Domestic Output	Direct Domestic Output	Indirect Output	Health Care Total Domestic Output
Gross Commodity Output	**1184.6**	**710.8**	**1895.4**	**2686.0**	**1516.8**	**4202.8**	6.0	5.6	5.9
Multiplier			**1.6**			**1.6**			
94 Hospitals	360.2	0.5	360.7	825.8	1.1	826.9	**6.1**	**6.6**	**6.1**
92 Offices of physicians, dentists, and other health practioners	285.3	0.1	285.4	597.0	0.1	597.1	**5.4**	**5.3**	**5.4**
79 Insurance	48.4	43.8	92.3	145.9	82.7	228.6	**8.2**	**4.6**	**6.7**
95 Nursing and residential care facilities	104.7	0.0	104.7	214.3	0.1	214.4	**5.3**	**5.2**	**5.3**
93 Other ambulatory health care services	73.6	15.8	89.4	170.6	35.5	206.1	**6.2**	**6.0**	**6.2**
62 Retail trade	64.1	5.8	69.9	182.8	5.7	188.5	**7.8**	**-0.1**	**7.3**
85 Professional, scientific and technical services	15.2	67.1	82.3	33.0	151.3	184.3	**5.7**	**6.0**	**5.9**
61 Wholesale trade	23.0	41.0	64.0	105.0	60.7	165.7	**11.5**	**2.8**	**7.0**
80 Real estate	1.9	69.2	71.1	3.7	161.0	164.7	**5.0**	**6.2**	**6.2**
88 Administrative and support services	1.6	50.9	52.5	3.7	130.0	133.7	**6.1**	**6.9**	**6.9**
27 Pharmaceuticals	47.9	29.1	77.0	82.5	34.1	116.6	**4.0**	**1.1**	**3.0**
87 Management of companies and enterprices	0.0	25.3	25.3	0.0	116.5	116.5	**-**	**11.5**	**11.5**
91 Home health care services	47.5	0.0	47.5	88.1	0.0	88.1	**4.5**	**2.2**	**4.5**
107 General government industry	28.4	0.0	28.4	65.2	0.0	65.2	**6.1**	**-**	**6.1**
77 Banks, credit cards and finance	0.0	18.7	18.7	0.0	55.2	55.2	**-**	**8.0**	**8.0**
58 Medical equipment and supplies, dental labs	11.2	14.2	25.5	24.5	24.8	49.3	**5.7**	**4.0**	**4.8**
Other Commodities	71.6	329.2	400.8	143.9	657.9	801.8	**5.1**	**5.1**	**5.1**

Of course, the largest sources of value added in health care are the two principle health care sectors. In 2012, ambulatory health care generated $561.4 billion, which was 3.5 percent of GDP. Hospitals and nursing and residential care racked up $501.4 billion of value added, or 3.1 percent of GDP. This accounting cannot be complete, however. For example, if the NHEA counts pharmaceutical manufacturing and distribution as part of the "health care economy," shouldn't the value added and employment generated by those industries also be counted on the supply side? What about the value added and employment associated with the suppliers of those sectors?

Table 4 shows this full accounting. For instance, manufacturing contributed $172.0 billion of value added to health care in 2012, including pharmaceutical manufacturing. Wholesale and retail trade had $112.9 and $117.8 billion, respectively, of value added associated with health care provision. Each of these accounted for 0.7 percent of GDP. The insurance industry in 2012 produced $121.5 billion of health care value added, and the broader finance, insurance, real estate, and rental and leasing sector contributed $318.8 billion. Professional and business services contributed $298.0 billion. State and local government administration and enterprises (including publically owned hospitals and other health facilities) contributed $159.7 billion, another one percent of GDP.

Since the economy's Gross Domestic Product (GDP) is the sum of value added across industries, total value added is an important figure for measuring the impact of any given industry on the overall economy. In a closed economy (with no foreign trade), input-output algebra holds that the sum of value added required to supply any given amount of final demand will be equal to that final demand. In an open economy, however, some final demand and intermediate demand "leaks" abroad and is satisfied by the "import of value added" from other countries. These imports are financed either by exports or by foreign borrowing. In any case, we should expect that sum of value added will fall short of the sum of final demand.

In total, the health care value added grew by an average of 5.8 percent per year, increasing from $1,133 billion in 1998 to $2,496 billion in 2012. The domestic value added dedicated to health care production was 12.5 percent of GDP in 1998 and 15.4 percent in 2012.

Health Care Employment Requirements for Each Industry

To estimate health care employment by industry, we multiply industry total output requirements by the corresponding industry employment-to-output ratios. In addition to the BEA industry full and part-time employment by industry, the LIFT model industry employment adds self-employed workers. Because medical services have substantial self-employment, we used the LIFT employment to BEA industry gross output ratios:

$$hemp_j^{industry} = \frac{emp_j^{lift}}{q_j^{bea}} \times q_j^{industry} \qquad (11)$$

The results for all major industries and for the largest sub-industries are shown in Table 5. We see that ambulatory health care services and hospitals, nursing, and residential care facilities created about 11.1 million jobs in 1998 and 14.7 million jobs in 2012. These health care sectors employed about 10 percent of civilian workers in 2012, up from about 8.0 percent in 1998. As explained above, however, this accounting for employment is incomplete. For example, if a large and growing segment of the retail sector is devoted to the distribution of health care goods and services, then should an equivalent proportion of retail employment be assigned to health care?

The IO definition of health care employment includes some interesting formulations. For example, health care demand includes the retail margins of pharmacies when they sell prescription drugs and other medical goods. It does not include the retail margin on candy sold at a pharmacy. Thus, an individual cashier's job is classified as health care related when he processes the sale of a health care item but not a candy bar.

The rest of Table 5 provides figures for the broader definition of health care employment. In 2012, for instance, over 940 thousand manufacturing jobs supported health care consumption and investment. This represents 7.8 percent of the 12 million jobs in the manufacturing sector. Retail trade contributed over 2 million jobs, finance insurance and real estate over 1.2 million, and professional services 3.4 million. The input-output analysis also allocates upstream jobs to agriculture (101,000 for 2012), mining (17,000), and utilities (35,000). Government employment devoted to health care was nearly 2.5 million in 2012; most of those were devoted to public health activities, particularly state and local hospitals that employed 996 thousand people, according to the BLS.[15]

According to these calculations, the aggregate number of health care associated jobs was almost 28 million in 2012, up from 21 million in 1998. In terms of total U.S. civilian jobs, health care employment grew by an annual average of 2.1 percent during the period, compared to 0.3 percent for general employment. The health care share of employment rose from 14.7 percent in 1998 to 18.7 percent in 2012.

Figure 4 contrasts two recent estimates of health care employment with the results derived in this paper, as a percentage of total employment. Recently, Turner and Hughes-Cromwick (2013) used the BLS Occupational Employment Statistics (OES) to provide a detailed accounting of employment and compensation for the two major health care sectors. Their health care employment total for 2011 is equivalent to the BEA figure for these two sectors shown in Table 5. The authors acknowledge that this figures leaves out important health care jobs such as pharmacists working in pharmacies and production workers assembling medical equipment. It also leaves out indirect jobs in distribution, mining, and utilities.

In a recent report on health care macroeconomics and outcomes, Moses, et.al, (2013) provide a more comprehensive listing of health care jobs across a mix of industries and occupations for 2000 and 2011. They identify 21.6 million health care jobs for 2011. This presentation is useful, but in order to include health care-related insurance, manufacturing, and distribution jobs, the authors mix data sources and introduce double counting of jobs. For instance, under the occupations category, they identify 272 thousand pharmacists in 2011. These data come from the Bureau of Labor Statistics (BLS) Occupational Employment Statistics (OES). Under the classification of manufacturers and distributors, they list hundreds of thousands of jobs in "med tech," wholesale, and retail (pharmacies). The apparent source of these data is the BLS Employment, Hours and Earnings data set. Unfortunately, at least half of the pharmacist jobs from the OES data are part of the jobs reported by the EHE for these other sectors. Moreover, the authors' figures for insurance carriers and agents appear to encompass the administration of other types of insurance, while our numbers count only those jobs associated with health insurance margins. For these reasons, the Moses, et.al, numbers cannot be added across their categories. Thus, while their final number overstates the number of jobs they have identified, it still understates the number of health care related jobs in the economy.

[15] See the Bureau of Labor Statistics' Employment, Hours, and Earnings database.

Table 4: Domestic Health Care Value Added by Industry (Levels in Billions of Dollars)

	Health Care Value Added by Industry				
	1998		2012		1998-2012
BEA Industry	Billion $	% of GDP	Billion $	% of GDP	Rate
GDP	9,089.1	100.0	16,244.6	100.0	4.2
National Health Expenditures	1,208.9	13.3	2,793.4	17.2	6.2
Total Domestic Value Added by Industry	1,132.8	12.5	2,496.5	15.4	5.8
Agriculture, forestry and fishing	4.0	0.0	9.8	0.1	6.6
Mining	3.3	0.0	13.3	0.1	10.5
Utilities	12.0	0.1	17.4	0.1	2.7
Construction	15.3	0.2	36.9	0.2	6.5
Manufacturing	100.8	1.1	172.0	1.1	3.9
Durable manufacturing	35.9	0.4	64.0	0.4	4.2
Nondurable manufacturing	64.9	0.7	108.0	0.7	3.7
Wholesale trade	46.8	0.5	112.9	0.7	6.5
Retail trade	49.9	0.5	117.8	0.7	6.3
Transportation	15.7	0.2	30.7	0.2	4.9
Information	25.6	0.3	49.6	0.3	4.8
Finance, insurance, real estate, rental & leasing	133.6	1.5	318.8	2.0	6.4
Insurance carriers and related activities	57.0	0.6	121.5	0.7	5.6
Professional and business services	104.1	1.1	298.0	1.8	7.8
Education, health care and social assistance	496.7	5.5	1,078.3	6.6	5.7
Ambulatory health care services	258.6	2.8	561.4	3.5	5.7
Hospitals and nursing and residential care facilities	229.8	2.5	501.4	3.1	5.7
Arts and recreation	2.0	0.0	5.2	0.0	7.2
Accomodation and food services	8.1	0.1	19.4	0.1	6.5
Other services, except government	12.7	0.1	20.4	0.1	3.4
Government Administration and Enterprises	102.2	1.1	195.8	1.2	4.8
Federal general government	7.4	0.1	16.9	0.1	6.1
State and local general government	81.5	0.9	159.7	1.0	4.9

Table 5: Health Care Employment by Industry (Levels in Thousands of Jobs)

	Health Care Employment by Industry				
	1998		2012		1998-2012
BEA Industry	Thousand Jobs	% of Total Employment	% of Total Employment	% of Total Employment	Growth Rate
Total U.S. Civilian Employment	142,372	100.0	149,270	100.0	0.3
Total Health Care Employment*	20,969	14.7	27,941	18.7	2.1
Agriculture, forestry and fishing	93	0.1	101	0.1	0.6
Mining	20	0.0	17	0.0	-1.2
Utilities	45	0.0	35	0.0	-1.7
Construction	321	0.2	464	0.3	2.7
Manufacturing	1,051	0.7	943	0.6	-0.8
Durable manufacturing	479	0.3	437	0.3	-0.7
Nondurable manufacturing	572	0.4	507	0.3	-0.9
Wholesale trade	480	0.3	683	0.5	2.6
Retail trade	1,243	0.9	2,002	1.3	3.5
Transportation	283	0.2	346	0.2	1.5
Information	198	0.1	177	0.1	-0.8
Finance, insurance, real estate, rental & leasing	874	0.6	1,231	0.8	2.5
Insurance carriers and related activities	577	0.4	729	0.5	1.7
Professional and business services	2,127	1.5	3,352	2.2	3.3
Education, health care and social assistance	11,369	8.0	15,082	10.1	2.0
Ambulatory health care services	4,646	3.3	6,723	4.5	2.7
Hospitals and nursing and residential care facilities	6,441	4.5	8,038	5.4	1.6
Arts and recreation	43	0.0	66	0.0	3.1
Accomodation and food services	340	0.2	533	0.4	3.3
Other services, except government	388	0.3	454	0.3	1.1
Government: general and enterprise	2,094	1.5	2,454	1.6	1.1
Federal general government	93	0.1	114	0.1	1.5
State and local general government	1,796	1.3	2,115	1.4	1.2

5. Summary Macroeconomic Results

A macroeconomic summary of the supply side accounting is provided by Table 6. A close examination of these figures helps to enhance the understanding of the process, its implications, and its weaknesses. The first line shows total NHE in nominal dollars and as a percent of GDP. Total nominal expenditures grew by an average compound annual rate of 6.2 percent from 1998 to 2012, reaching 17.2 percent of GDP in 2012.

The second line in Table 6 shows that direct demand for imports increased by 11.2 percent per year, growing from 2.0 percent of NHE in 1998 to 3.8 percent in 2012. Recall that Table 2 showed that about $53 billion, or 64 percent, of the $83 billion increase in direct imports is attributed to pharmaceuticals. Final health care demand from domestic production grew by an average of 6.0 percent per year, lagging overall NHE growth a bit because of import penetration. It still reached 16.5 percent of GDP by 2012.

After solving for domestic total output demand requirements, we find that the multiplier on domestic demand is 1.6. The annual 6.0 percent increase in direct output slightly outpaced the 5.6 percent annual increase in indirect output. Again, this mostly is due to increased import penetration, as indirect imports increased at a rate of 8.7 percent per year. At $137 billion in 2012, indirect imports are actually larger than direct health care imports of $107 billion. Value added is calculated by multiplying the industry total output requirements by the observed industry value added to output ratios for each year. The total value added rose from 12.5 percent of GDP in 1998 to reach 15.4 percent in 2012.

Figure 4: Health Care Employment as a Percent of Total Employment: Three Estimates

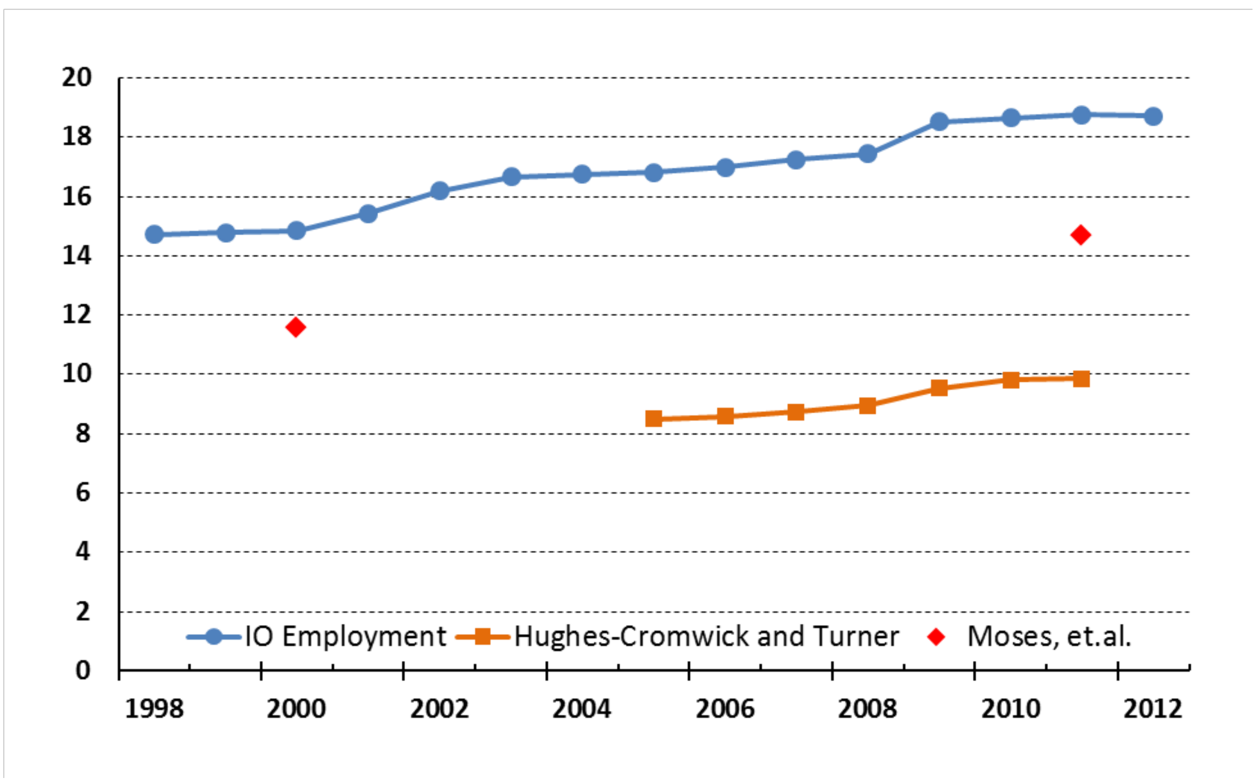
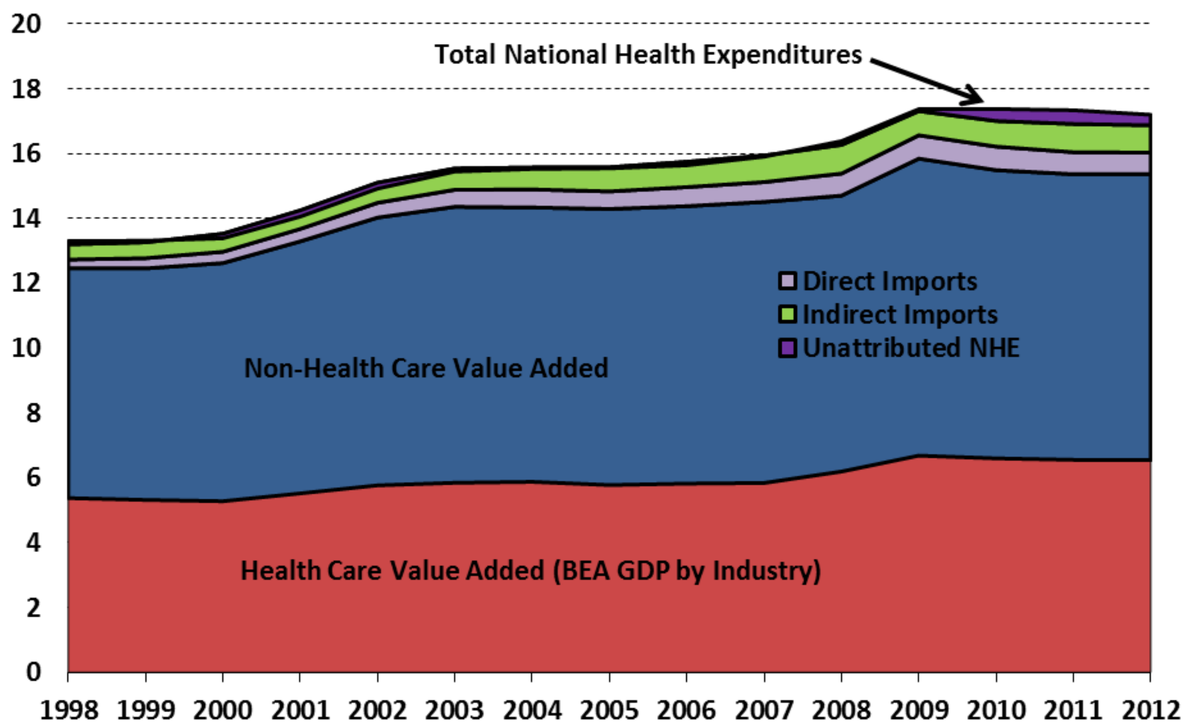


Table 6: Summary Reconciliation between NHE and Heath Care Supply

	Levels (Billions)		% Change	Share of NHE		Share of GDP	
	1998	2012	1998-2012	1998	2012	1998	2012
National Health Expenditures (NHE)	1208.9	2793.4	6.2%	100.0	100.0	13.3	17.2
Direct Demand - Imports	24	107	11.2%	2.0	3.8	0.3	0.7
Direct Demand - Domestic Production	1,185	2,686	6.0%	98.0	96.2	13.0	16.5
Value Added	1,133	2,496	5.8%	93.7	89.4	12.5	15.4
Ambulatory care, hospitals, nursing	488	1,063	5.7%	40.4	38.0	5.4	6.5
Other industries	644	1,434	5.9%	53.3	51.3	7.1	8.8
Indirect Demand from Imports	43	137	8.7%	3.5	4.9	0.5	0.8
Unattributed Value Added	9	52	–	0.8	1.9	0.1	0.3
	Levels (Millions)		% Change	Share of Economy-Wide Employment			
	1998	2012	1998-2012	1998	2012		
Health Care Employment by Industry	21.0	27.9	2.1%	14.7	18.7		
Ambulatory care, hospitals, nursing	11.1	14.8	2.1%	7.8	9.9		
Other industries	9.9	13.2	2.1%	6.9	8.8		

Figure 5: The Macroeconomic Supply of Health Care (Percent Share of GDP)



Theoretically, total health care demand (NHE) is equal the sum of direct and indirect imports plus the domestic value added generated in satisfying final demand.[16] Table 6 and Figure 5 indicate that domestic

[16] The sum of direct and indirect imports represents the value added contribution of foreigners to U.S. health care. These imports are earned through current or future exports.

value added attributable to health care production accounted was 93.7 percent of NHE in 1998 and 89.4 percent in 2012. Direct imports added 2.0 percent in 1998 and 3.8 percent in 2012, and indirect imports were 3.5 percent of NHE in 1998 and 4.9 percent in 2012. In this exercise, the unattributed value is a measure of inaccuracies of the process. Much of this error is due to simplifying assumptions, such as the assumption that the import share for goods and services are constant across categories of intermediate and final demand. The discrepancy is small, with values of 0.8 and 1.9 percent of NHE in 1998 and 2012, respectively.

6. Conclusion and Future Research

There is a common assertion that health care accounts for more than one-sixth of the economy. This conclusion, however, is based on a measure of health care demand that NHE shows to be 17.2 percent of GDP. It is much more difficult to identify this ratio in the supply-side economic data, that is, in terms of value added and employment.

The methodology presented here reconciles this health care demand and supply discrepancy. We use input-output techniques to link the final demand values from the NHE accounts to domestic production and imports of commodities, industry value added, and industry employment. In addition to the traditional health care sectors, we find that the provision of health care involves substantial direct production from manufacturing, insurance, wholesale and retail trade, non-health care services, and government. Furthermore, we trace indirect health care production and employment across virtually all sectors of the economy. We find that in 2012, health care production required about 15.4 percent of total value added and 18.7 percent of civilian employment. In addition, domestic health care demand required about 1.5 percent of GDP in imports.

These calculations are made using published BEA industry and input-output data that are subject to the normal caveats of using detailed national accounting data. We also make several simplifying assumptions to apply this data for the present task. Nevertheless, we find that the results are plausible and provide a useful illustration of how the large and growing health care sector relates to the overall economy.

We have several tasks for future research. First, we will update the LIFT database with the new 2007 benchmark IO table and the associated integrated industry data that was released in December 2013.[17] The integrated data will provide greater consistency across the IO, industry, and NIPA accounts. This will simplify the operations and should reduce some of the error introduced by inconsistencies in the older database.

Second, we plan to provide a breakdown of employment by occupation. The LIFT model currently contains a matrix of occupation-by-industry that is an aggregation of the BLS Office of Employment Projections 2010 occupational matrix. However, in order to provide an accurate health care occupational breakdown for sectors such as chemicals and retailing, this matrix will need careful recalibration. To extend the matrix across time, we hope to use the BLS OES data.

In addition, the health care supply side framework provides new ways to examine productivity growth in the sector. For example, we can construct a new measure of health care productivity growth by dividing real NHE value added by a measure of full-time equivalent labor. This ratio then can be compared to various other aggregate productivity indices, and the results have important implications for the sustainability of the current health care expenditure trends.

[17] See Moyer, Planting, Fahim-Nader, and Lum, (2004); Lawson, Moyer, Okubo, and Planting, (2006); and Moyer (2009).

Finally, we intend to extend the supply side measures into the future using the short-run (to 2022) and long-run (to 2087) NHE expenditures projections published annually by CMS. Because of the large volume of input-output parameters to be estimated, these projections are much more complicated. While LIFT makes such projections routinely, the current health care application will require a close evaluation of the underlying data for credibility and consistency. The benefits of such projections will be great, however. Like the historical data, the carefully scrutinized NHEA projections provide only demand-side detail. Yet if these projections are to be evaluated for plausibility, it is their supply side trajectories that are more important.

7. Appendix: The LIFT Model of the U.S. Economy

The Inforum approach to modeling attempts to provide both the dynamics and high-level accounting of macroeconomic models and the industry structure featured in the general equilibrium approach to modeling. The Long-term Interindustry Forecasting Tool (LIFT) is a dynamic general equilibrium representation of the U.S. national economy. It combines an interindustry input-output (I-O) formulation with extensive use of regression analysis to employ a "bottom-up" approach to macroeconomic modeling. In this way, the model works like the actual economy, building the macroeconomic totals from details of industry activity, rather than by distributing predetermined macroeconomic quantities among industries. For example, aggregate investment, total exports, and employment are not determined directly, but are computed as the sum of their parts: investment by industry, exports by commodity, and employment by industry. LIFT contains full demand and supply accounting for 110 productive sectors.[18]

This bottom-up technique provides several desirable properties for analyzing the economy. First, the model describes how changes in one industry, such as increasing productivity or changing international trade patterns, affect related sectors and the aggregate quantities. Second, parameters in the behavioral equations differ among products, reflecting differences in, for instance, consumer preferences, price elasticities in foreign trade, and industrial structure. Third, the detailed level of disaggregation permits the modeling of prices by industry, allowing one to explore the causes and effects of relative price changes.

Another important feature of the model is the dynamic determination of endogenous variables. LIFT is an annual model, solving year by year, and it incorporates key dynamics that include investment and capital stock formation. For example, investment depends on a distributed lag in the growth of investing industries and international trade depends on a distributed lag of foreign price changes. Moreover, parameter estimates for structural equations largely are based on time-series regressions, thereby reflecting the dynamic behavior of the economic data underlying the model. Therefore, model solutions are not static, but instead they project a time path for the endogenous quantities. The LIFT model thus simulates the economy year-by-year, allowing analysts to examine both the ultimate economic impacts of projected energy or environmental policies and the dynamics of the economy's adjustment process over time.

Despite its industry basis, LIFT is a general equilibrium model, using bottom-up accounting to determine macroeconomic quantities that are consistent with the underlying industry detail. It includes macroeconomic variables that are consistent with the National Income and Product Accounts (NIPA) and other published data. This macroeconomic "superstructure" contains key functions for household savings behavior, interest rates, exchange rates, unemployment, taxes, government spending, and current account balances. Like many aggregate macroeconomic models, this structure is configured to make LIFT exhibit "Keynesian" demand-driven behavior over the short run but neoclassical growth characteristics over the longer term. For example, while monetary and fiscal policies and changes in exchange rates can affect the level of output in the short-to-intermediate term, supply forces – available labor, capital, and technology – will determine the level of output in the long term.

The LIFT model thus is particularly suited for examining and assessing the macroeconomic and industry impacts of the changing composition of consumption, production, foreign trade, and employment as the economy grows through time.

The interindustry framework underlying the model is composed of five blocks: final demand, supply, factor income, prices, and the accountant. The first block of LIFT uses econometric equations to predict the behavior of real final demand (consumption, investment, imports, exports, and government

[18] Additional details may be found in Meade (2002).

expenditures). The components are modeled at various levels of detail. For example, aggregate consumption is the sum of 83 consumption products, and aggregate construction investment is the sum of expenditures for 19 types of private structures. Demand by product, with product sectors consistent with the input-output table (A matrix), is determined using bridge matrices to convert final demand to the commodity level. Following Wilson (2001), this equation is specified as:

$$f_{110} = B^{C}_{110\times 83} c_{83} + B^{E}_{110\times 65} e_{65} + B^{S}_{110\times 25} s_{25} + g_{110} + v_{110} + x_{110} - m_{110}$$

where B represents a bridge matrix for the various components (consumption, equipment investment by purchasing industry, and construction by type[19]) and where remaining variables represent consumption by product, equipment investment by purchasing industry, structures by type, inventory change, exports and imports, and government spending.

In the supply block, these detailed demand predictions then are used in an input-output production identity to calculate real gross output:

$$q = A \times q + f$$

where q and f are vectors of output and final demand by commodity, respectively, each having 110 elements, and where A is a 110x110 matrix of input-output coefficients. Input-output coefficients and the bridge matrix coefficients vary over time according to historical trends evident in available data and, in some cases, using assumptions about how technology and tastes might develop in the future (2008).

Commodity prices are determined in a similar fashion. In the factor income block, econometric behavioral equations predict each value-added component (including compensation, profits, interest, rent, and indirect taxes) by industry. Labor compensation depends on industry-specific wages that are determined by industry-specific factors as well as overall labor market conditions. Profit margins are dependent on measures of industry slack (excess supply or demand) and, for tradable sectors, on international prices. Depreciation depends on capital stock levels. Indirect taxes and subsidies are imposed, in most cases, through exogenous ad-valorum rates on overall nominal output.

The industry value added levels are allocated to production commodities using a make matrix. Then the fundamental input-output price identity combines value added per unit of output with unit costs of intermediate goods and services to form an indicator of commodity prices:

$$p' = p' \times A + v'$$

where p and v have 110 elements to represent production prices and unit value added, respectively. This identity ensures that income, prices, and output by sector are directly related and are consistent. In turn, relative prices and income flows are included as independent variables in the regression equations for final demand, creating simultaneity between final demand and value added.

As noted above, LIFT also calculates all of the major nominal economic balances for an economy: personal income and expenditure, the government fiscal balance (at both the federal and state and local government levels), and the current account balance. It also contains a full accounting for population, the labor force, and employment. This content is important for building alternative simulations because it ensures consistency between economic growth determined on the product side and the inflation and income

[19] Note that some details presented here are simplified accounts of actual the actual model, such as the presentation of the government demand vector. Government spending by commodity type within the model is the constructed as sum of several bridged demand vectors that provide detail for federal defense, federal nondefense, and state and local spending.

components. The model allows us to examine how alternative microeconomic conditions or policies will affect other aspects of the economy. Because the input-output structure allows a bottom-up approach to modeling the macro economy, macroeconomic results fully are consistent with simulated industry disruptions.

Recent projects include analyses of the effects of the sequester and other recent changes to fiscal policy (Werling, Fiscal Shock: America's Economic Crisis, 2012) and analysis of the harm done by policies that allow deterioration of infrastructure (Werling, Failure to Act: The Economic Impact of Current Investment Trends in Airports, Inland Waterways, and Marine Ports Infrastructure, 2012). Long-run economic effects of technological development were assessed in Meade (2010), in the case of vehicle electrification, and in Meade (2009) for the case of policies that encourage technological development to combat climate change. Examples of impact analysis conducted with the Lift model include a study of the economic effects of port closures following a terroristic attack (reported in Arnold, et al., (2006)) and in two private studies) and the economic impacts of the September 2001 attacks (2009). Other studies of macro and industry impacts of supply constraints include the "Macroeconomic and Industrial Effects of Higher Natural Gas Prices" (Henry & Stokes Jr, 2006) and "Immigration Impacts on the U.S. Economy."[20]

[20] The Inforum study of immigration was delivered to the Department of Commerce in 2006. For additional discussion of the Inforum modeling methodology in relation to Vector AutoRegression (VAR), Computable General Equilibrium (CGE), and other approaches to economic modeling, see Wilson (2003), Grassini ((2005) and (2005)), and Almon (2008). For a survey of methodology and input-output techniques, see Almon, et al. (1974), Almon (1991), McCarthy (1991), Manprasert (2004), and Almon (2008). Details on consumption modeling are available in Almon ((1979) and (1998)), Chao (1991), Bardazzi and Barnabani (2001), and Li (2006). Wilson ((2001), (2003)) describes modeling of productivity and employment. Details on treatment of international trade in the Inforum modeling system are presented in Nyhus (1991) and Qing (2000). Many of these papers and additional details and references may be found on the Inforum web site: www.inforum.umd.edu.

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